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ANALYSING AND RECTIFYING THE SLUGGISH MOVEMENT OF GEARBOX IN AN AUTOMOBILE MANUFACTURING INDUSTRY USING QUALITY ASSURANCE TOOL

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ABSTRACT

This research paper aims at the analysis of various problems, more specifically sluggish movement in the transmission system of an automobile and rectify the problem. The transmission system of an automobile is a mechanism which provides the necessary speed and torque to the vehicle. Transmission of an automobile is made of gear and gear trains. The various combinations of these gears produce different types of speed ratios and torque. The problems in the gearbox occur because of many gears and intricate parts working together in a synchronized way, as we know that more the number of moving parts more will the complexity. All the parts of a gearbox are necessary for the proper functioning of gearbox we cannot get rid of them, in fact, what we can do is to analyse the cause of the problem and then try to rectify it. The sluggish movement in the gearbox lead to reduced efficiency of the gearbox and decrease the overall performance of the vehicle and also leads to reduced fuel economy. Sluggish movement causes bumpier rides in a vehicle and discomfort during commuting. Rectifying the sluggish movement is very important for the proper functioning of the gearbox and the vehicle.(Khodabakhshian, Feng, & Wikander, 2013)

KEYWORDS: Gearbox, Sluggish Movement, Fishbone Diagram, Transmission & Piston

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Original Article

INTRODUCTION

What is Sluggish Movement?

Sluggish movement in gearboxes is defined as the time lag between the forward-reverse clutch engagement responses. In simple words, we can understand this problem through a practical example. Suppose the Backhoe Loader in running in forwarding motion and the operator requires reverse motion. This need of him makes him to apply reverse gear for the required motion. Now, if the loader responds to the action with agility then it's no problem, but if there is a considerable time lag between the application of gear and response of the same then there is some problem i.e. Sluggish movement. (Ibrahim, Albarbar, Abouhnik, & Shnibha, 2013)

A car transmission system is a part which experiences the most wear and tear than any other parts of the vehicle due to intense heat which is produces due to the interaction between the gears and many other components. These parts work continuously at very high rpm, these are the reasons why the gearbox undergoes sluggish movements and many other problems. Some of the problems other than sluggish movement are discussed below.

Whining, Clunking and Humming

These sounds come when the parts of the gearbox undergo wear and tear. The gearbox starts to produce a

constant humming sound while the engine is on, and the clunking sound is produced by the gearbox whenever the gear is changed. These sounds are more prominent in a manual transmission system. It is wise to take appropriate decisions to repair the gearbox in an early as early as possible because if you chose to do it later then it will wear more and consume more money.

Leaking or Low Fluid

The transmission fluid is the key element in the functioning of the transmission system, without transmission oil the gearbox will seize to work and in response to that, the engine will also stop working. Automatic transmission fluid is a bright red color oil if there is oil on the ground under the standing vehicle then it is clear that oil is leaking. All we have to do is to fix the hole from where it is leaking. After fixing the hole we should check how much oil is leaked, after doing so we should refill the transmission fluid again.

Burning Smell

The transmission fluid is responsible for the lubrication between the parts of the transmission and also act as a cooling agent. It maintains the optimum temperature of the gears so that they do not undergo distortion. If there is bad quality of oil in the gearbox then it is a possibility that it can reach its breakdown temperature and starts to degrade which leads to very high temperature. The components of gearbox undergo thermal distortion due to very high temperature and gearbox starts to malfunction. Burning smell also comes when the temperature gets to high due to low oil in the gearbox.(Lei, Lin, Zuo, & He, 2014)

Transmission

Transmission is a mechanism which provides us suitable variation form of engine torque at wheels. This is achieved by gearbox.

Important Parts of Transmission

- **Rear Case**

It is that part of gearbox which is connected with the rear case with prop shaft and universal coupling. For coupling, it is provided with the yoke. A gear named as transfer gear is inserted in a rear case which works as fourth gear or O/P gear because this transmits the power to rear axle.

- **Front Case**

This is connected to the engine with the help of torque converter. Two valves named as pressure maintaining valve & pressure regulating valve are bolted in it. Strainer (75 microns) which works for initial cleaning of transmission oil is also attached to it.

- **Main Shaft**

This shaft is equipped with three gears in the solid rotation and one gear in free rotation named as third gear. This shaft is always in mesh with reverser unit and is the main for the engagement of third and fourth gear. This is provided with a synchronizer too.

- **Lay Shaft**

This shaft always meshes with main the shaft. This is equipped with third and second gear. This shaft is again having a synchronizer. Third and second gears are free rotating while two gears are in the solid rotation.

- **Reverser Assembly**

This is the most important assembly in transmission. This assembly consists of five friction and counter plates, two pistons, two gears etc. it is used to drive the vehicle in forward and reverse modes. It can be named as the clutch for a vehicle. JCB is using multiplate, wet type double clutch system.

- **Synchroniser**

It is the necessary part of a synchromesh gearbox. It performs the function of converting free rotation of first, second and third gear into a solid rotation. It rests on hub sleeve. When any of the gear is chosen, it comes in action and its outer hub which is teethed internally comes over free gear (chosen) and provides solid rotation from that.

- **Piston Seal Rings**

Four polytetrafluoroethylene seal rings are used to get their berth inside reverser shaft rings. It is required that these must sit completely otherwise these may be cut on assembling mating parts. These are important for isolating hot oil moving towards cooler. Moreover, these serve the purpose of avoiding the leakage of pressure so that problems of clutch non-engagements can be avoided.

- **Selector Shaft with Block**

Two selector shafts are used in JCB's four-speed gearbox. These shafts with blocks are attached to gear change lever to change the gear. For different gears and three positions of the synchronizer, there are three slots in selector shaft.

- **Pressure Maintaining Valve**

As JCB is using a hydraulically operated gearbox, therefore it is important to have a clear and significant way for oil travel for clutch operations. So, a hub of paths for forward, reverse and neutral conditions flow is named as an adapter. This adapter at one of its end is having a valve which can be tightened and loosened to set for any value of pressure.

- **Solenoid**

A three position, four ports spring cantered solenoid is used to sense the vehicle requirement and accordingly send the transmission oil in forward, reverse clutch or in the tank (sump) directly in neutral mode.

- **Filter**

As it is quite important to dodge the possible contamination of oil used in transmission for the longevity of the vehicle. Therefore, besides strainer, there is the provision of a filter too. The oil sucked by charging pump is first made to pass through a filter and then to other parts.

- **Speed Sensor**

It is also a part of gearbox which shows vehicle speed in km/hr.

- **Torque Converter**

The construction of torque converter is similar to that of fluid coupling; the only difference is that there is an additional stationary member called stator. It is used to increase the torque in a ratio of about 2:1 to2.7:1. It is used to transmit torque from engine to gearbox. It has three parts:

- Impeller or driving member connected to the engine.
- Turbine or driven member connected to wheels through the transmission.
- Stator fixed with the help of a freewheel clutch.

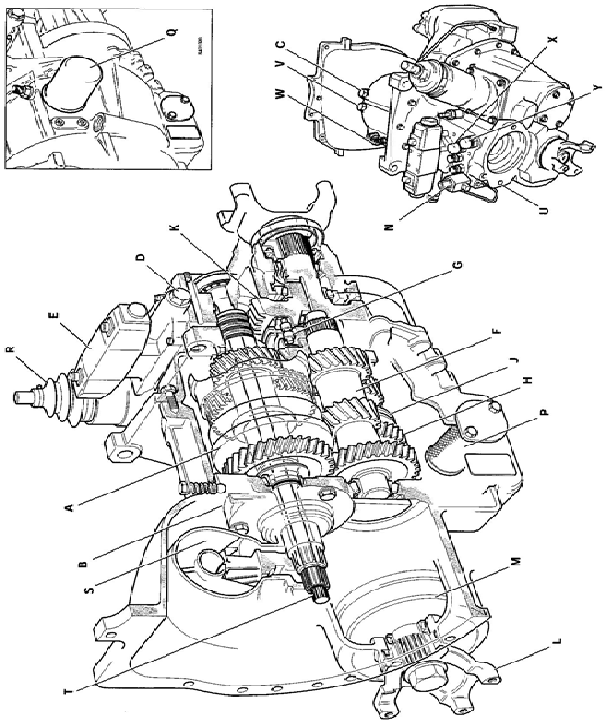

Figure 1: Cross Sectioned View of Gearbox

METHODOLOGY

Observations Undertaken to Reach Main Causes of Sluggish Movement

Several cases of a sluggish movement were considered and all of them shown below are the main attributing factors for this problem.(Praveenkumar, Saimurugan, Krishnakumar, & Ramachandran, 2014)

Table 1: Main Causes of Sluggish Movement

S. No.	Observations	Actions
1.	Machine not moving in forward direction but no problem in reverse direction.	Solenoid valve changed but didn't work.
		Gearbox opened, checked and Oil baffle found damaged due to fouling with gear with carrier plate (31 teeth) on one side, piston worn out at one side. Therefore, oil baffle reworked and piston replaced.
		Machine operation found ok.

Table 1: Contd.,		
2.	Time lag of 5-7 seconds was reported in a machine.	Gearbox opened, checked and Piston found broken, oil baffle Got damaged due to spring as well. Therefore, piston was changed and oil baffle too.
		Machine operation found ok.
3.	Time lag of 5-7 seconds observed in a machine in reverse to forward motion while no problem in the motion from forward to reverse motion.	Gearbox opened, checked and oil baffle was found sticking with spring due to contamination on the former, 'O'ring found cut and compressed. Oil baffle was reworked and new 'O'ring was placed.
		Machine operation found ok.

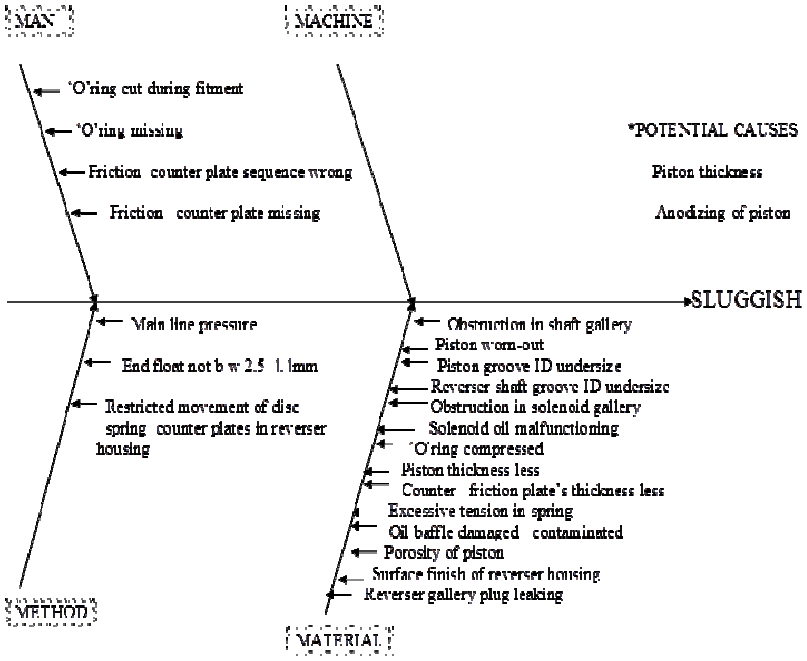

Figure 2: Fishbone Diagram for All Possible Root Cause of Sluggish Movement

Main Reasons of Sluggish Movement after Inspection

Although a lot of root causes considered theoretically on the possible basis, but a few found the most effective elements to result in the said problem and those are:

Damage of Oil Baffle Due to Spring or Improper Transportation

After proper inspection of gearbox on dismantling due to this problem, one of the factors taken to cause this problem was oil baffle. The possible damage of oil baffles during transportation external or internal of the company ambience and less care during handling of oil baffles during assembly was thought to be the problem in action. Besides, the damage even after assembly due to fouling with gear (31 teeth) is the major one to resolve.

Contamination of Oil Baffle

The slow action of the machine may be because of contamination of oil baffle. It is contamination which plays a

concerned role in the motion of wheel even in the neutral mode and the time lag in mode reversals-how? Contamination makes the clutch engagement more persistent that it works in the same mode even when mode is changed-that's why machine although instantly but moves even in neutral mode, after working for some time.

Piston Conditions

In most of the undertaken cases for study, the conditions of the piston are found to be affecting this glitch. The concerned problems with piston are a usage of the broken piston (either prior or due to piston fragility), contaminated piston, the presence of compressed or cut O ring in piston groove, the absence of spherical rollers in piston grooves which helps in pressure maintenance and cooling as well.(Praveenkumar et al., 2014)

Id and Od of Oil Baffle

Oil baffle used is having its inner diameter approx. 64.8-65.0mm which produces a radial clearance of about 0.7-0.8mm. Besides this OD of the baffle is also much more than OD of spring. This type of design may avail baffle movement in a plane perpendicular to the plane of pressure application. This in turn designs an eccentric assembly. Thus, a time lag could possibly be there to lesson this movement.

Solenoid Spool Sticking

Solenoid is the element which checks the system requirement and then directionally controls the transmission oil flow for forward, reverse and neutral mode of the m/c. Oil has to flow each time through its galleries while the path of spool and spring could be not as smooth as it is at the time of installation. This could be only due to possible contamination of transmission oil or due to rusting of spring (prior or oil caused). Hence this can be an active factor for this problem and the same problem can be responsible for the reduction in forward and reverse mode pressures, causing sluggish.(Bobzin et al., 2015)

IMPROVEMENTS SUGGESTED AFTER INSPECTION

Damage of Oil Baffle Due to Spring

- Guiding tool can be used for spring assembly and baffle.
- Spring shouldn't be put in random motion over the baffle.
- A force b/w 985-1204N can be applied on the spring.

Damage Due to Improper Transportation

- When provided to the operator, oil baffles must be in bins provided with separators.
- During long-distance transportation, these can be well wrapped in paper for its safety.

Contamination of Oil Baffle:

- Oil baffle can get contaminated primarily by the oil used in gear-boxes. So, to avoid contamination and hence produced sticking b/w baffle and spring, the hydraulic oil must be tested for contamination.
- Oil baffle can be contaminated not only by itself but also by its surroundings. So, all appurtenances nigh to the baffle like piston, spring and baffle seat should be without dirt or foreign material.

- Shop floor and ambience cleanliness can too help a lot.

Piston Diameters and Piston Conditions

- Piston diameter where oil baffle is assembled should be 63.3-63.4mm which will reduce the radial clearance with oil baffle ID.
- Piston shouldn't be broken. For this, a little care can be taken by logistics distribution center (LDC) during transportation and by the operator during assembly.
- Piston with 'O' ring should be used strictly.
- Operator must take proper care that compressed or cut O ring should not be used.
- Anodizing the piston can help it to dodge contamination.
- Operator should see whether spherical rollers are present or not in the piston.

Id and Od of Oil Baffle:

- ID of the baffle can be reduced to 64mm approx. to achieve concentricity.
- Adjusting the OD of oil baffle to 81.9-82.1mm so that a genuine radial clearance of 0.45-0.65mm would be there. This can possibly avoid the chances of baffle fouling with gears (31T and 22T). ID of these gears is 83-83.2mm.
- Proper inspection gauges for checking ID and OD in the quality department can help to maintain consistent performance against the problem of sluggish movement.

Figure 3: Eccentricity Present

Figure 4: Eccentricity Absent

Solenoid Spool Sticking

- All the machined galleries of rear case and the front case must be clear. For this pressurized air flow through all the galleries should be implemented by line operator before assembly.
- To avoid possible contamination of spring and spool, a fresh set of spring and spool should be used, which are kept in a packing just after spraying them with rust resisting chemical.

Others

- Sequence of friction and counter plates, their quantity should not change.
- End float should be checked for each reverser unit on both sides.
- Disc spring shouldn't be incorporated in the non-splined region of reverse housing.

- Thickness checking for friction & counter plates should be done.(Rassokha & Isaychev, 2017)

RESULTS AND DISCUSSIONS

Following are the results obtained by analyzing and rectifying the sluggish movement in the gearbox of an automobile

- After analyzing and rectifying the problem the forward and reverse movement of the gearbox and the vehicle was achieved.
- Time lag of 5 to 7 seconds in the response of the gearbox was rectified and the lag was reduced to 1 second. For completely remove the time lag more inspection was needed and more money will be involved in that process, so that it was accepted that 1 second lag was manageable.
- After rectifying the problems regarding the transmission fluid, the noise from the gearbox was reduced to a negligible level. The gearbox was functioning properly after refueling the branded oil and maintaining the optimum amount of fluid in the gearbox.

Analysis of the gearbox shows us the many aspects of the sluggish movement of the gearbox. We get to know about what sluggish movement actually is and how it affects the functioning of the gearbox and the vehicle as a whole. The gearbox optimum functioning does not only depend on rectifying the sluggish movement but it also depends on many other factors such as fluid level in the gearbox, burning smell, Whining, Clunking and Humming, Leaking or Low Fluid. After analysing the gearbox, we get to know that a transmission system needs maintenance after a specific interval of time if we continuously use the transmission system then the damage will be very high and incapable of repair. Then after complete failure, the cost of repair will be very high. It is wise to take notice of those symptoms which indicates the malfunctioning of the gearbox because we don’t want our vehicle to stop functioning in the middle of nowhere. There are many components of the transmission system which are discussed above and each component helps in its own way to let the gearbox to function properly. Study of sluggish movement requires us to study almost all the components of a transmission system.

CONCLUSIONS

At the end, we can say that if we take proper measures during the manufacturing process of a gearbox and maintain the strict quality standards such as six sigma standards then the problems can be minimized. We should take necessary steps during the manufacturing process so that the repair process will be not an overburden on the company. It was observed in the process of analyzing and rectifying the sluggish movement of the gearbox that almost all the problems can be solved after careful inspection and lot of the problems could be avoided if the company pays a little attention in the manufacturing process. The future aspect of this study is not limited only to solving gearbox problems but also any problems in the industry can be solved by analyzing the situation and then taking necessary steps to rectifying it.

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